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Designing computer-based rewards with and for children with Autism Spectrum Disorder and/or Intellectual Disability

ABSTRACT

Children with Autism Spectrum Disorder (ASD) tend to have an affinity for digital technologies, often preferring computer-assisted learning to human-assisted learning. Many children with ASD are also diagnosed with Intellectual Disabilities (ID), yet design studies involving children with ASD and ID are scarce. Rewards can have a positive impact on children's learning and motivation, but little is known about the nature and impact of rewards for children with ASD, and/or ID. Digital technologies are well placed to provide task-based rewards, and in combination with a better understanding of the reward preferences of children with ASD and/or ID this has significant potential to enhance learning. This paper presents two robust participatory design (PD) studies involving children with: i) ASD; ii) ID; and iii) both ASD and ID. The studies aimed to identify: i) the reward preferences of children with ASD and/or ID (RQ1) and ii) how rewards might develop throughout a task as the child progresses (RQ2). Results revealed a number of reward categories that were common to all children, as well as children's preferences for how rewards could develop as they progress through computer-based tasks, for the first time. Original implications for designing computer-based rewards embedded within digital intervention/educational technologies for children with ASD and/or ID, are discussed.

1 Introduction

The relationship between rewards, motivation, engagement and performance is complex and continues to spark controversy and debate (Cerasoli et al., 2014). Historically, Deci (1971) has categorized motivation as either: a) *extrinsic* (driven by an external reward, e.g. a certificate); or b) *intrinsic* (driven by enjoyment and personal interest). While intrinsic motivation is considered to be “an important construct, reflecting the natural human propensity to learn and assimilate” (Ryan & Deci, 2000, p. 54), there is also evidence that extrinsic motivation brings benefits, particularly for children with neurological differences (Johnson & Picard, 2016; Mancil & Pearl, 2008). External rewards have been shown to stimulate participation and enhance task performance (Lai, 2011; Eisenberger & Cameron, 1996). They can also increase the enjoyment of the task, particularly if the reward promotes a sense of competence after doing a ‘good job’ (Myers, 2007). Whilst the effect of rewards on intrinsic motivation has been controversial, one interesting finding is that participants often report that extrinsic rewards are useful for keeping them engaged (Wolters & Benzon, 2013).

Digital technology has been shown to be an ideal medium for providing extrinsic rewards (Fletcher-Watson, 2016; Humphry, 2011; Cramer et al., 2011). Digital reward systems are commonly used within computer games to provide positive feedback and enhance user engagement (e.g. Cruz et al, 2015; Goh et al, 2017). These systems typically involve players accumulating points or badges in recognition of certain actions, achievements or task completion. Whilst some theories (e.g. self-determination theory) suggest that extrinsic rewards might harm players' intrinsic motivation there is also research suggesting that such systems can actually be intrinsically motivating and may also provide additional benefits such as boosting self-esteem (see Cruz et al, 2015). Moon et al (2011) lend credibility to the use of game reward systems in learning programs to promote self-regulated learning. The authors examined different reward systems of digital games and investigated the possibility of using similar reward systems in the

context of learning systems to promote motivation. Within educational settings digital reward systems enable greater consistency and immediate notification of the child's achievement compared to paper-based reward systems (Cramer et al, 2011).

The research on rewards reported in this paper is being conducted within the context of creating technologies to deliver behavior/perspective change interventions to children with autism and/or ID. Currently few technological solutions to these interventions exist, and consequently teachers rely on the medium of paper for the interventions and their associated rewards, for example using sticker charts. In many classrooms, especially larger ones, a paper-based system requires significant teaching effort to monitor and maintain. Thus, the provision of rewards can be inconsistent both within classrooms and also across teaching professionals. A computer-based reward system can help avoid such inconsistencies and subjectivity. Also, it can take time for the teacher to perceive the achievement and administer the reward and delays between activities and rewards can diminish the effectiveness (Cramer et al., 2011). Well-designed, in-built systems of reward within digital technology have the potential to be more effective by overcoming such delays. Additionally, a computer-based reward system can offer an extensive choice of rewards, which can be personalized to the child's needs and interests, and enhanced by adding features, such as animations or sound.

Given their well-documented affinity with technology and their special interests, children with Autism Spectrum Disorder (ASD) may be particularly receptive to digital rewards embedded within software. ASD is defined by persistent deficits in social communication and interaction, combined with restricted and repetitive behaviors and interests (APA, 2013). Computers can act as an interface between the individual with ASD and other people, ameliorating social communication and interaction deficits (Brosnan & Gavin, 2015) and reducing social anxiety (Moore et al., 2005; Williams et al., 2002; Cobbs et al., 2002). Computers also offer the opportunity to modify the environment, for example by eliminating or reducing information that might distract attention from the main task, and allowing children to work at their own pace (Williams et al., 2002). Additionally, computers, including multi-touch tablets (Hourcade et al., 2013; Sampath et al., 2012), have been found to be appealing for children with ASD, resulting in benefits such as increased motivation, attention and learning compared with traditional methods (Goldsmith & LeBlanc, 2004; Bosseler & Massaro, 2003).

In addition to an apparent affinity for digital technology, extrinsic rewards can also have a positive impact on motivation and task performance for children with ASD (Johnson & Picard, 2017; Koegel & Egel, 1979; Mancil & Pearl, 2008; O'Dell et al., 1983; Humphry, 2011). Rewards are especially important for individuals with ASD since they are more prone to failure than typically developing children, due to their social communication and interaction deficits (Clark & Rutter, 1979). It has also been suggested that intrinsic motivation may not be sufficient to overcome sensory demands and environmental distractions required for learning and task completion, and therefore extrinsic rewards are necessary (Johnson & Picard, 2017). Such rewards have been found to be particularly motivating when related to the individual's restricted interests (Mancil & Pearl, 2008). Humphry (2011) argues that a computer-based intervention needs to reward appropriate behavior in order to maintain the learner's interest and that planning a reward strategy is crucial for any intervention with children with ASD. Despite this, studies within this area are scarce (Humphry, 2011; South et al, 2005).

In a small study with three children with ASD Humphry (2011) found that the children displayed the highest level of motivation, focus and accuracy when their favorite reward type was presented. She also found a high degree of variability regarding the children's reward preferences highlighting the need for a variety of choices in order to meet the diverse range of interests of the individuals with ASD. Despite these individual preferences, there are preferred topics popular with people with ASD. In a study involving 19 individuals with Asperger Syndrome (AS), and 21 with high-functioning autism (HFA), aged 8 to 20 years, South et al. (2005) found that the topics of major interest were

consistently similar in both groups. The most popular topics were: Japanese animation (e.g. Pokemon), Gadgets/devices, Dinosaurs, Space/Physics, Natural disasters, Historical events, Power rangers/Ninja Turtles, Encyclopedias/fact books, and Playing videogames. Thus, whilst there is variety in preference for reward instances in people with ASD, there is consistency in the topic categories from which the reward instances originate. Whilst this research identified the most popular topics for rewards to be drawn from, there is a lack of research in supporting children in designing their own rewards, and in identifying whether and how rewards should change with progress for children with ASD.

Technology is well-suited to both personalizing the topic of the reward and reward adaptivity. However, there appears to be an absence of literature on the latter aspect, which may be crucial to continued motivation to engage with the technology, learning and task performance. In addition, technology is well placed to satisfy the need for a variety of choices of rewards. As a preference for sameness can be characteristic of the restricted and repetitive behaviors and interests that define ASD, how rewards might adapt as a task progresses is particularly pertinent for this group.

Finally, much of the design research to date has been undertaken with highly able people with ASD (e.g. Fabri et al, 2016; McAllister & Sloan, 2016; South et al, 2005). However, 44-52% of children diagnosed with ASD also have developmental deficits in intellectual and adaptive functioning - Intellectual Disabilities (ID) (APA, 2013; NAS, 2016). Hence it is important to understand the requirements of children with and without ID when developing digital rewards for children with ASD. Although children with ASD have social communication and interaction deficits, they are able to effectively participate in the design of digital technologies, when the participatory design sessions are structured appropriately (Benton et al., 2011; Benton et al., 2012). Similarly, though challenging, children with ASD and ID can contribute to participatory design (PD) sessions (Börjesson et al., 2015; Keay-Bright, 2012; Keay-Bright & Horwarth 2011; Hourcade, Bullock-Rest, & Hansen, 2012).

The underlying context for the studies reported in this paper relate to our main research goal: to develop, in collaboration with children with ASD, software to support the delivery of Social Stories¹ (Gray, 2010) as a perspective taking/behavioral intervention. The system will be used by children, their teachers and parents and will, if required, enable personalized and potentially adaptive/progressive rewards to be tailored to individual children. The development of the system affords the opportunity to consider: i) if, and how rewards enhance engagement, motivation and learning by children with ASD and/or ID, and ii) if rewards that adapt to learning or other progression are of benefit to a population with a preference for sameness and consistency. The current paper presents two studies focused on designing digital rewards with three groups of children, those with: i) ASD; ii) ID; and iii) both ASD and ID, through PD sessions. By involving and comparing the three groups we hope to identify similarities and differences across the groups in terms of their design preferences and to address the following research questions:

RQ1: What are the preferred rewards of children with ASD, ID, or ASD and ID?

RQ2: As a characteristic of children with ASD is a preference for sameness and repetition, *how might digital rewards adapt or develop (if at all) as children progress through a task?*

¹ Social Story is a short story with a specific style and format that describes a situation, a social skill or a concept in a meaningful way for individuals with ASD.

2 Research study design

The research was reviewed and approved by the Psychology Ethics Committee at the University of [removed for blind peer review]. A brief overview of the research study design is presented in Table 1 below. The specific methods used within the studies are described in Section 3.2.

Study	Aims	Methods	Participants	RQ
Study 1 (3 x 60 minute sessions)	1. To identify what kinds of reward children liked. 2. To collect, discuss and prioritize ideas for rewards. 3. To explore the design space and refine the reward requirements.	Interacting and Exploring the app Brainstorming ideas Creating a prototype	3 children with ASD	1 and 2
Study 2 (1 x 60 minute session)	1. To discover what types of reward children with ASD and/or ID prefer. 2. To explore how rewards could be developed and presented in a technology-based intervention.	Questionnaire Card sorting Creating a prototype of reward ideas	12 children (4 with ASD, 4 with ASD and ID, and 4 with ID)	1 and 2

Table 1: Summary of the research studies

3 Study 1

3.1 Participants

Participants were recruited through a special school for children with ASD and/or ID, located in [removed for anonymity]. The inclusion criteria for the children in the first study were:

1. A diagnosis of ASD;
2. Fluent in English;
3. Aged 11 to 15 years².

Details of the children involved in the first study are presented in Table 2. These students were class colleagues. The children had communication skills at the level expected of a child aged 6 to 9 years. This was assumed to be attributable to a diagnosis of ASD, as they did not also have a diagnosis of ID.

Part.	Age	Gender	Diagnosis	Communication Level Speaking (S)/Listening (L)
C1	12	M	ASD	2C*
C2	12	F	ASD	3B*
C3	12	M	ASD	3C*

Table 2: Summary of participants' details in the first study (*According to the UK National Curriculum)

Three adults (two Researchers and a Teaching Assistant who was familiar with the children) were present to individually support children in their activities.

3.2 Research methods and materials

Study 1 comprised three x 60 minute sessions, held within the children's school on different days.

² In the UK, at the end of Key Stage 2 (age 11), children are expected to obtain a "4B" level (4A is above average, 4C below average). At the end of Key Stage 1 (age 7), children are expected to obtain a "2B" level (2A is above average, 2C is below average).

Session 1

Whilst literature exists that suggests that children with ASD and/or ID appear to appreciate and want rewards, we did not want to automatically make this assumption of our population of participating children. Consequently, Session 1 was specifically designed to provide preliminary evidence as to whether the children would appreciate and want rewards within intervention/educational technologies. The children were asked to explore/interact with two applications for Social Story interventions. One application 'StoryMaker' is an iPad application developed by HandHoldAdaptive (2016), and the other, 'Improving Social Interaction through Social Stories' (ISISS), a desktop application (Constantin et al., 2013). Only ISISS had a reward system embedded within it. After interacting with the applications, children were asked, regardless of the technology used and the different systems, if they liked/wanted to have rewards included within the applications. Children were also asked what kinds of reward they liked in computer-based systems and their suggestions were noted down (e.g. children can change the text reward, children can choose the picture reward, fireworks at the end for celebration reward) for developing in Session 2.

Session 2

The second session aimed to address RQ1, considering reward preferences. Brainstorming techniques, (Maguire, 2001) were used to gather spontaneous ideas about rewards and to identify if children with ASD have preferred rewards. After an icebreaker activity, children received paper notes, pencils, and a selection of images to inspire them (Figure 1, right), based on their ideas in the previous interaction/usability feedback session. Each child was invited to write down their ideas on paper notes and then to stick them on an A3 worksheet (Figure 1, left). The ideas collected from the children in session 1 as well as questions to think about, were added to the worksheet to inspire children in generating new ideas (Figure 1, left). Each child received their own colored pen (different from each

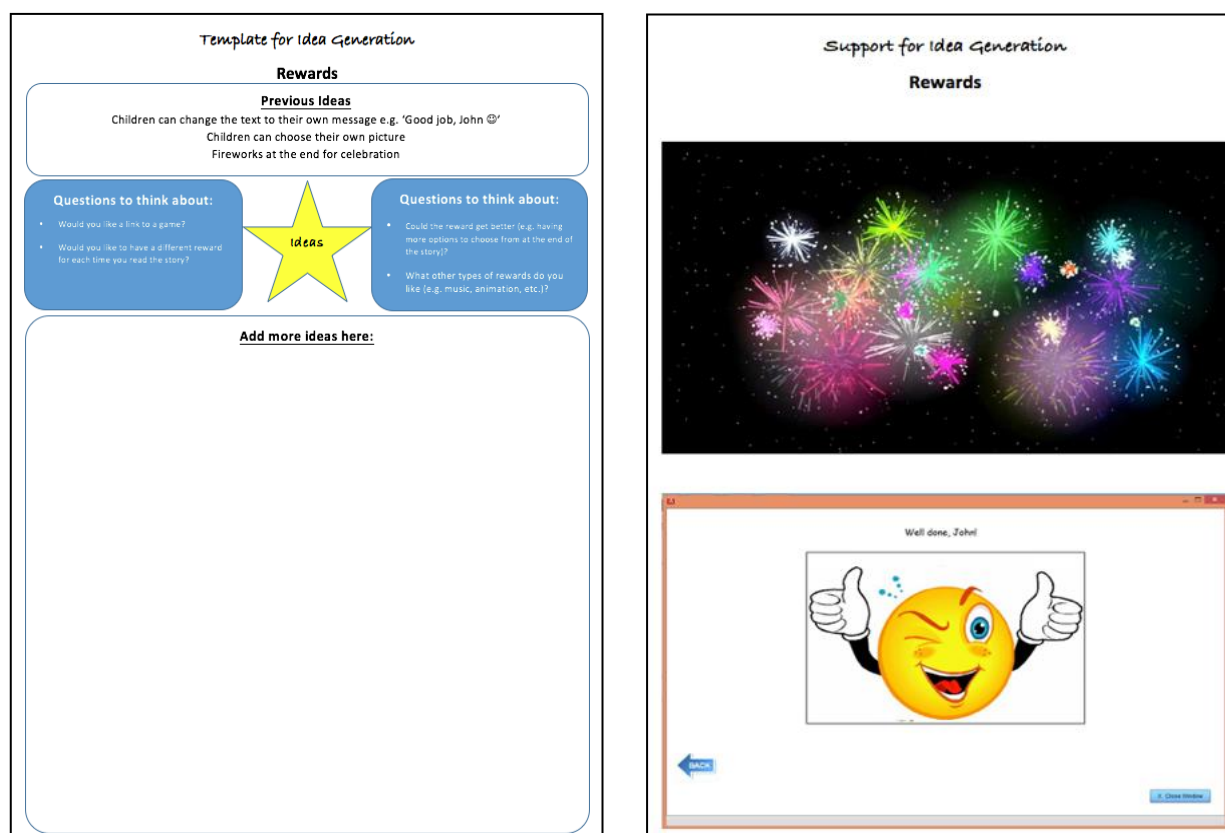


Figure 1: Support materials for Idea generation: [left] worksheet; [right] images to support children in generating ideas on “rewards” topic

other) so they could easily identify their own ideas. The adults were present to provide support, answer questions and scribe for the children where necessary. Only one of the children required the adult to scribe for them.

After collecting the ideas, children were asked to provide more detail about them. For this activity each child received a role: a) interviewer who asked questions following scripts provided by the researchers; b) interviewee who answered the questions, and c) cameraman operator. Children swapped roles in order that each child played each role, had the opportunity to answer questions, explain their ideas and select her/his favorite reward idea.

Session 3

The third session aimed to address RQ2, considering the possible adaptation and development of rewards associated with child progress. It consisted the following activities:

1. *Introduction*: The researchers introduced the session, explaining what the children were expected to do during the session.
2. *Choosing a topic*: The “reward” ideas generated during the previous session were presented to the children. Children were asked to discuss and group them into two piles: a) choices of rewards to be used within the system; and b) rewards that could develop linked to progress. This activity aided children in remembering ideas for rewards suggested in the brainstorming session and to clarify these by commenting and classifying them. They were then invited to choose one idea they found most interesting from the first category in order to individually build a reward prototype.
3. *Building a reward*: Each child worked independently to present their chosen reward ideas on a sheet of paper. They received numerous paper sheets with an iPad outline, colored pencils, screenshots from other applications, sheets with interface features such as buttons, boxes, menus and other drawings, to be cut and added to the prototype.
4. *Presenting the prototype I*: Each child presented her/his prototype both verbally and visually. For this activity children undertook the following roles: a) presenter – the one who presented her/his work; b) director – the one who asked questions about the prototype; c) cameraman operator. For the director role the researchers provided scripts with questions. The children were also encouraged to ask their own questions, with one child in particular making good use of this opportunity.
5. *Building a reward that develops*: Children were asked to work together to build a prototype where the reward could adapt/develop in response to their progress. They received the same materials as in the third activity to support them in building the prototype.
6. *Presenting the prototype II*: Two of the children played the role of co-presenters, while the third child played the director role asking questions about the prototype. Scripts were provided for the director, but again the child was encouraged to ask their own questions.

3.3 Data collection and analysis

All three study sessions were video recorded and the videos were transcribed for analysis. The transcripts were analyzed using NVivo, a platform for qualitative data analysis, provided by QSR International (QSRI, 2016). The notes and prototypes created by children were manually coded (see Figure 2), and the results were collated with the results obtained from using NVivo.

Data was analyzed using a combination of qualitative methods from the first and second cycle coding methods as described by Saldaña (2013). The first coding cycle contains methods that are used in the initial coding of data. They are fairly simple and direct and consists of assigning a word or a short phrase that capture the essence of a portion of language-based or visual data. In contrast, the second coding cycle, requires analytic skills, such as classifying, prioritizing, integrating, synthesizing, and abstracting. For Session 1 data, magnitude coding was employed. This is a method from the first coding cycle, which allows basic statistical information to be attached to the data to indicate frequency, intensity, direction, presence, or evaluative content. In this study, symbols were used (e.g. '+', '-', and 'N') to note whether the participant made a positive, negative or neutral comment regarding their preference for using a reward within an intervention/educational computer-based application. For RQ1 and RQ2, the transcriptions were first coded using open coding or initial coding that seeks to identify concepts in data by closely examining discrete parts. This was followed by axial coding, a method from the second coding cycle in which similar open codes are grouped into conceptual categories, based on the relationships between them.

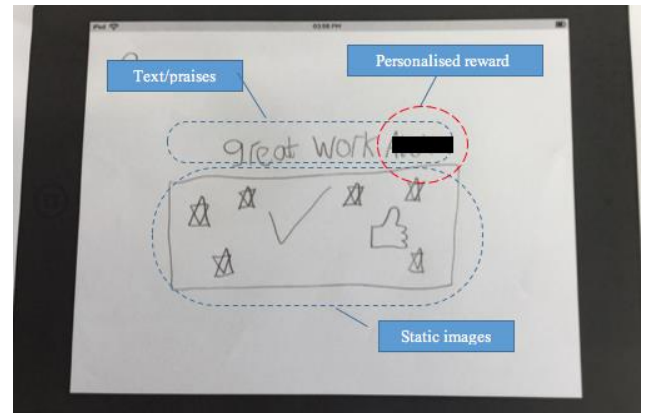


Figure 2: Example of a prototype manually coded

3.4 Results

All three children with ASD who participated in Session 1 of Study 1 answered that they would prefer to receive a reward regardless of the technology used:

“Yeah...children can choose their own pictures, fireworks at the end to celebrate”. (C3)

The analysis did not bring out any negative or neutral comment regarding rewards.

RQ1 What are the preferred rewards of children with ASD? (Study 1 only considered children with ASD)

Children were able to express their preferences about the types of rewards they would like and how to use them within the applications:

“... you could have had like fireworks popping out and stuff like that to make it like you’ve done it and its really good and you could still have that smiley face saying ‘Well done Jane’ or ‘Brilliant Jane’. Something like that.” (C2)

With respect to the choice of reward to include in a system, two children’s prototypes were similar to one of the screenshots provided as support materials. However, they illustrated it in a different way: C1 drew a smiley face and added many stars and a text message (“Great work, William”), whereas C2 created a “silly, funny” face, adding stars, sound effects (“Bang”), and text messages (“Well done!”, “Great job, Jane”, “Have fun, Jane”). C3 opted for a game as a reward and drew a pyramid with the text message (“Harry, well done”).

Two key themes emerged from the analysis of this data:

1. Reward choices - children would prefer to choose their own reward from a variety of choices;
2. Development of a reward - children would like the reward to change over time (e.g. in magnitude) to reflect the child's progress.

The rewards suggested by the children included:

- a) static images (e.g. own photo, smiley and silly faces, superhero characters, stars, flags, thumbs up, tick symbol when a child chooses a correct answer) (3 children);
- b) text (e.g. "Well done, Andrew!", "Great work, Jane!") (3 children);
- c) sounds (e.g. character voices, own recorded voice, parent's recorded voice, music) (3 children);
- d) animation (e.g. characters flying, animated words) (2 children), fireworks (3 children)³.

RQ2: As a characteristic of children with ASD is a preference for sameness and repetition, how might digital rewards adapt or develop (if at all) as children progress through a task?

The children made a number of suggestions relating to how a reward might develop over time:

"fireworks at end that can become bigger and bigger each time you read the story" (C3),

"rewards get better, for example more super-heroes" (C1),

"a silly face, then the tongue sticks out, and then the character says something" (C2).

In the last activity, regarding rewards that develop with progress, children illustrated a "silly, smiley" face as a reward that develops (Figure 3). They represented three levels of the reward with each level reflecting the child's progress. Children magnified the face from one level to another, and added different messages to emphasize the achievement: "Well done", "Good job, Jane", "Amazing job, William". Child C2 explained:

The heads are growing bigger. [...] They have to write name. And- And when it finishes, if they did good, they have the middle one pop up, and if they were actually really, really good, they'd have a big one pop up.

Consistently, children personalized their text messages, using their own names (e.g. "Great job, Jane"). (N.B. Names changed for anonymity)

The initial study therefore identified important characteristics for embedding rewards within technology designed for children with ASD. However, the small number of children in this and many other studies, is a major limitation in allowing us to make any generalizations or design suggestions from these results. As noted in the introduction, many children with ASD also have an additional diagnosis of ID. For these

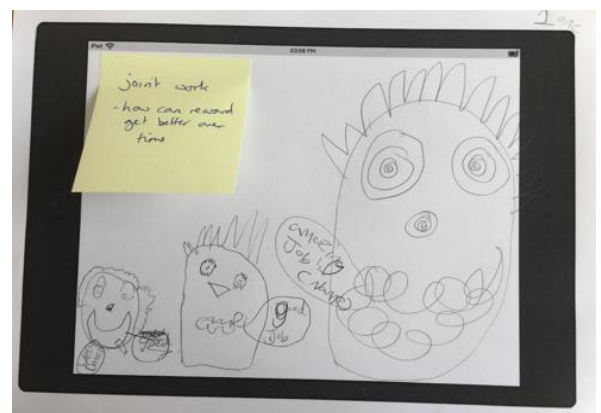


Figure 3: Reward that develops created by children

³ Children also suggested links out of the software to games and movies. The focus of the analysis was on rewards presented and developed within a system, though this option is of interest for future research.

two reasons, a second study sought to examine whether there were any differences in the preferences of those with ASD, with ASD and ID, and with ID alone.

4 Study 2

4.1 Participants

For the second study, participants were recruited from the same school and in the same manner as Study 1. The inclusion criteria for the children were:

1. a diagnosis of ASD, or ID, or both ASD and ID;
2. aged 11 to 15;
3. did not take part in Study 1.

As noted in Study 1, children with a communication level of 2B had communication skills expected of a 7-year-old based upon national SAT assessments (2C below this, and 1A lower again). Table 3 highlights that the ASD children and the ID children had communication skills equivalent to children around 5 or 6 years younger than their chronological age. Children who have not obtained the basic skills are progressing towards these skills and are awarded P-grades from P1 to P8. As can be seen from Table 3, the ASD with ID group were all progressing towards the basic communication skills expected of a 7-year-old.

Part.	Age	Gender	Diagnosis	Communication Level Speaking (S)/Listening (L)
G1_1	12	F	ASD, ID	P8/ P6
G1_2	13	M	ASD, ID	P3/ P4
G1_3	11	M	ASD, ID	P8/ P6
G1_4	12	F	ASD, ID	P3/ P4
G2_1	13	M	ASD	2C*
G2_2	12	M	ASD	2C*
G2_3	13	F	ASD	2B*
G2_4	13	M	ASD	2C*
G3_1	12	M	ID	2B*
G3_2	13	M	ID	1A*
G3_3	13	F	ID	2C*
G3_4	12	M	ID	2C*

Table 3: Summary of participants' details in the second study.

(**P3**=pupils begin to communicate intentionally; **P4**=speaking between 10 and 50 single words/signs/phrases, or using objects of reference or symbols (S), understanding at least 50 words (L); **P6**=initiate and maintain short conversations (S), respond to other in group situations (L); **P8**=link up to four key words, signs or symbols (S), take part in role play with confidence (L); *According to the UK National Curriculum Levels)

This study involved 12 children (8 males and 4 females), who formed three groups, according to their diagnosis: G1) four children with ASD and severe ID; G2) four children with ASD; G3) four children with mild ID. Demographic details, as well as details about children's communication level are presented in Table 3.

4.2 Research methods and materials

The second study extended Study 1 by including children with ID and children with both ASD and ID in order to investigate any differences that might exist between the groups.

Prior to Study 2, the first author met class teachers to find out if children would be able to follow these study activities, to discuss the reward instance 'appropriateness' (in terms of children's interests and

familiarity with the objects/events represented in the image). Suggestions for improving the study were also noted. The suggestions made by the teachers were followed in the sessions. The teacher of the students with ASD and ID (Group 1) advised using only the second activity (selecting an instance from the favorite topic categories), explaining that her students are unable to understand and be involved in the other activities. She also advised preparing at least two instances (noted a & b - see Table 5) from each category of rewards, suggesting some images she knew that children could recognize. This teacher suggested excluding the category “Historical Events”, as her students cannot understand the concept. The second teacher confirmed that all her students (ASD, Group 2 and ID, Group 3) could likely perform all the activities. Both teachers suggested that they should work individually with the children, rather than the researchers. This was primarily to help the children feel at ease and less inhibited when answering questions. Also, the teachers knew better how to approach each child and what language to use when communicating with them.

Study 2 contained three main activities. The first activity was designed to *identify the children’s favorite reward topics*. It began by identifying preferences within the nine topics outlined by South et al. (2005) referred to in the introduction of this paper, i.e. Japanese animations (e.g. Pokemon), Gadgets/devices, Dinosaurs, Space/Physics, Natural disasters, Historical events, Power rangers/Ninja Turtles, Encyclopedias/fact books, and Playing videogames. The second activity was to *identify a specific instance from each favorite reward topic* that children liked. These two activities were created to address the first research question presented earlier about reward preferences (RQ1). The third activity was designed to see if the children could *create a reward that adapted or developed*, if wanted, thus addressing the second research question (RQ2). The activities were as follows:

1. *Selecting the favorite topic categories of rewards*. Using a worksheet (W1) containing a list of the 9 categories of rewards, children were asked to select their favorite categories by ticking the corresponding cell (see Figure 4). If they had another preference, they could write it down at the end of the list. This activity was performed by all children simultaneously. Children were encouraged to ask questions for clarifications. The class teacher and one researcher were present to help children read the questions and clarify them if needed.

Worksheet 1	
Please tick the category of rewards you would prefer in the left column.	
Gadgets/devices	
Dinosaurs	

Figure 4: Excerpt from worksheet W1

2. *Selecting an instance from the favorite topic categories*. Each child was presented with 18 cards (see Figure 5), two instances of each of South’s 9 categories of rewards and asked to sort them into two groups: ones they liked, and ones they did not like/or are not sure they liked. The instances were chosen by the first author, based on their appropriateness as discussed with the teachers. After sorting the cards, the children were required to add them to the right hand cell on the W1 worksheet,

aligned with the corresponding category. For the favorite categories that did not have a corresponding instance selected from the cards, and for any newly added category, children were invited to use an iPad to search on the Internet for their favorite instance.

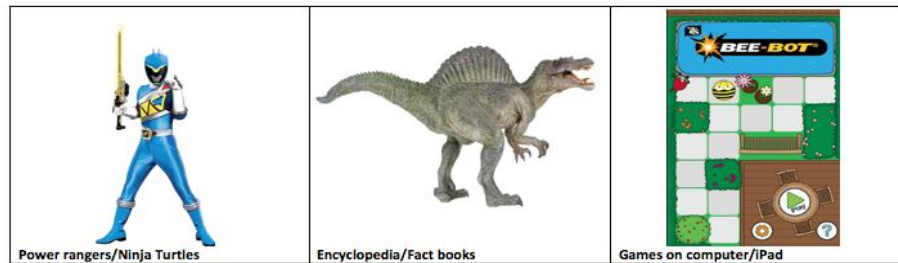


Figure 5: Examples of reward instances

3. *Building a reward that develops.* Using worksheet W2 (see Figure 6, left), children were asked to build different levels of, or changes to a reward that develops as the child progresses. Since the shortest Social Story interventions are around five sessions (for example, see Kokina and Kern, 2010), more than 5 levels of a developing reward was considered not to be appropriate. The children's teachers were also consulted and felt that five was an appropriate number of reward levels. Children were invited to use the reward instance (image) they liked most for the first level. For the next levels, children were asked, if they wanted to, to add various features to illustrate how they would like the rewards to change/develop. These features were taken from Study 1, namely animation, sound, fireworks, and text, which was labelled 'certificate of achievement' to highlight the rewarding nature of the text ('well done', good job' 'amazing'). Children received a set of cards each with a visual representation of possible features to be added to worksheet W2 for the corresponding level (Figure 6, right). These were based on the types of rewards collected from the brainstorming session in Study 1. Participants were also encouraged to add anything else that they wanted to add.

Worksheet 2				
Level 5 (top)				
Level 4				
Level 3				
Level 2				
Level 1				
Add your favourite reward here				

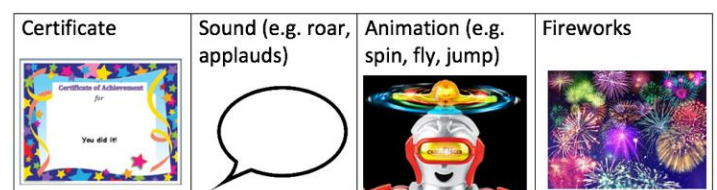


Figure 6: [left] worksheet W2; [right] visual representations of the features

4.3 Data collection and analysis

Video-recordings and transcripts of the sessions enabled the researchers to identify the children's preferences for each topic category (or instances in the case of group 1) of reward across the three groups. Patterns in building rewards that develop, were also explored for children in groups 2 and 3. For these last two groups, the reward preferences resulting from the card sorting were compared with the preferences for the topic categories of rewards resulting from completing worksheet W1.

The data collected from Activity 1 (based on the worksheets W1) were summarized in a table (see Table 4) where, for each child, the preference for a specific topic was marked with a tick and the preference which differed from the 9 topics were included in a separate column. The table also included the total number of preferences for a specific topic within each group, as well as the total number of preferences for all children. For Activity 2, the video recordings were carefully watched and the preference for an instance from a specific topic was marked with a tick for that topic in a table (see Table 5), adding also the specific chosen instance (e.g. a or/and b). Other preferences (different from the selected topics) and the most liked rewards were recorded in separate columns. Again, the number of preferences for each topic within a group, as well as the total number of topic preferences (for all children) were calculated. Finally, based on data collected from Activity 3, each feature frequency was calculated for each level within each group. Also, all the ideas for rewards and features were selected and grouped into categories.

4.4 Results

RQ1: What are the reward preferences of children with ASD, ID or ASD and ID?

The first two activities aimed to address RQ1. Results from activity 1 are presented in Table 4 below. This task was completed by children in groups 2 and 3 only.

Part.	PR/NT	ND	JA	GC	D	E/FB	S/P	G/D	HE	Others
G2_1	✓	✓	✓	✓	✓			✓		Dragons
G2_2		✓		✓		✓	✓	✓	✓	Horse riding
G2_3				✓	✓			✓		Pets
G2_4	✓	✓					✓	✓	✓	Pirates
Total G2	2	3	1	3	2	1	2	4	2	N/A
G3_1	✓	✓	✓	✓	✓		✓	✓		Drama performing
G3_2	✓			✓			✓	✓	✓	Starwars
G3_3	✓		✓	✓	✓	✓	✓	✓		Cats & dogs
G3_4		✓			✓			✓	✓	Spiders
Total G3	3	2	2	3	3	1	3	4	2	N/A
Total	5	5	3	6	5	2	5	8	4	N/A

Table 4: Activity 1 – Selecting the favorite topic category of rewards

(PR/NJ=Power Rangers/Ninja Turtles, ND=Natural Disasters, JA=Japanese Animations, GC=Games on Computer, D=Dinosaurs, E/FB=Encyclopedias/Fact Books, S/P=Space/Physics, G/D=Gadgets/Devices, HE=Historical Events, ✓=stands for a favorite category)

The category G/D (Gadgets and Devices) was considered a favorite topic for all children in groups 2 and 3. There was also a high preference for GC (Games on Computers) across the two groups. Low scores for E/FB (Encyclopedias/Fact Books) was also consistent across the groups.

The second activity, undertaken by all three groups, involved card sorting instances from favorite topic categories into 'likes' or 'dislikes/unsure'. Results are presented in Table 5 below. Consistent with the results of the first activity G/D (Gadgets and Devices) and GC (Games on Computers) were the most

popular, scoring 11 and 10 respectively. Again there are no notable differences between the three groups.

Part.	PR/NT	ND	JA	GC	D	E/FB	S/P	G/D	HE	Others	Most liked
G1_1		✓ a	✓ a&b	✓ a&b	✓ a&b		✓ a&b	✓ a	N/A		Dinosaurs
G1_2	✓ b	✓ b	✓ b	✓ a			✓ a		N/A		Not sure
G1_3				✓ a&b	✓ a&b		✓ a	✓ a	N/A	Drawnimal (iPad game)	Angry Birds
G1_4	✓ a		✓ a			✓ a		✓ a	N/A		Not sure
Total G1	2	2	3	3	2	1	3	3	N/A	N/A	N/A
G2_1	✓ a	✓ a	✓ a	✓ a	✓ a			✓ a		Dragons	Dinosaurs
G2_2		✓ a		✓ a		✓ a	✓ a	✓ a	✓ a	Horse riding	Books
G2_3				✓ a	✓ a			✓ a		Pets	Pets
G2_4	✓ a	✓ o		✓ a			✓ a	✓ a	✓ a	Pirates	Ninja turtles
Total G2	2	3	1	4	2	1	2	4	2	N/A	N/A
G3_1	✓ a	✓ a	✓ a	✓ a	✓ a		✓ a	✓ a		Drama performing	iPad
G3_2	✓ a			✓ a			✓ a	✓ a	✓ a	Starwars	Starwars
G3_3	✓ a		✓ a	✓ a	✓ a	✓ o	✓ o	✓ a		Cats & dogs	iPad
G3_4		✓ a			✓ a			✓ a	✓ a	Spiders	Spider
Total G3	3	2	2	3	3	1	3	4	2	N/A	N/A
Total	7	7	6	10	7	3	8	11	4	N/A	N/A

Table 5: Activity 2 - Card Sorting (favorite topic instances)
(a=fist image instance, b=second image instance, o=other instance selected by the child from Internet,
✓ =instances that are 'liked')

RQ2: As a characteristic of children with ASD is a preference for sameness and repetition, how might digital rewards adapt or develop (if at all) as children progress through a task?

Activity 3 focused on RQ2. This study provided children from groups 2 and 3 with a set of features to build a developing reward. These features were selected taking into account the results of Study 1. Most of the children used all the features with which they were provided. Child G2_1 and G3_4 did not use fireworks, and child G3_2 did not use certificates, preferring instead to add vocal messages to the reward. The results show that the favorite feature added at the second level was animation (preferred by four children, two with ASD and two with ID), whereas a certificate was preferred for the third level (twice by children with ASD and once by a child with ID) with the same frequency as sound (chosen once by a child with ASD and twice by children with ID). Sound outnumbered the other features at level 4 (two children with ASD and 3 with ID). Finally, the fireworks feature was the favorite at the last level, followed by a certificate (see Figure 7).

The findings are clearly mixed and with small numbers, meaning no definitive conclusions can be drawn. For this small cohort, taken together, there seems a slight preference for the following progression: 1) still image; 2) additional animation; 3) additional sound/certificate; 4) sound; 5) fireworks/certificate (see Figure 7). However, in the third level a certificate is preferred more by children with ASD, whereas sound is preferred more by children with ID. In the final level fireworks is preferred more by children with ASD and a certificate is preferred more by children with ID.

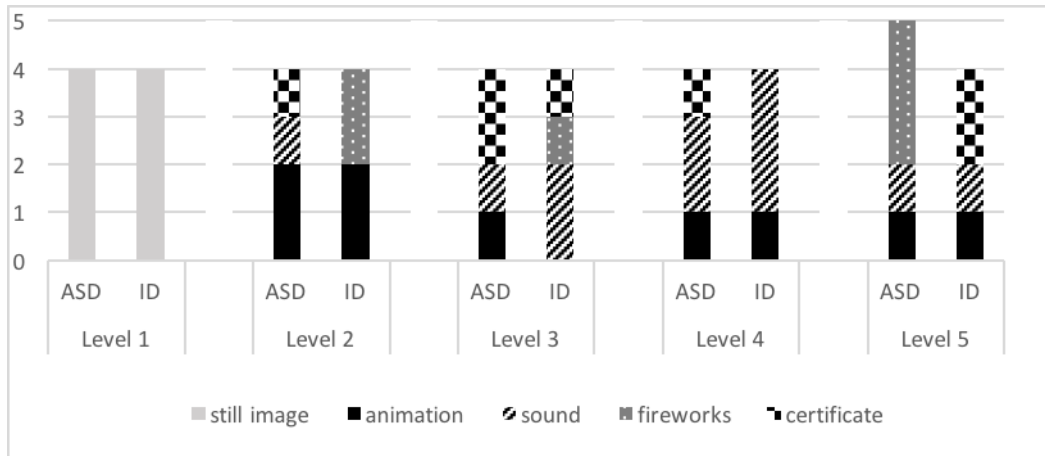


Figure 7: Feature preferences in the “Building a reward that develops” activity

A question remains concerning what the children understand about changes to the rewards and the relationship to, or association with, progression. All that can be said is that generally children understand that rewards can change and are willing to demonstrate how they would like rewards to change. None of the children said they would prefer the rewards to remain the same throughout all the levels.

Children suggested various ideas for animation that were specific to the image (e.g. book opening, dog dancing, dinosaur fighting another dinosaur), sound (e.g. spider taps, dog barking, character saying praising words), and for text messages on certificates (e.g. “Well done”, “You are a star, Mike”, “Thank you, Daniel!”). Thus, as in Study 1, there is a degree of personalizing the development of the rewards to the topic and to the specific child (e.g. “Well done, Andrew” rather than “Well done”).

5 Discussion

Our primary research aim was to better inform how rewards should be embedded within digital technology to motivate children with ASD. This paper reports on two participatory design studies completed with children with ASD and/or ID in order to investigate their reward preferences regarding an educational/interventional digital platform. We were particularly interested in identifying i) the kind of rewards children want and appreciate within digital technology, and ii) how the rewards should develop, if at all.

The findings from Study 1 were clear. Children with ASD do prefer technologies with embedded extrinsic rewards and the capacity to select from choices of rewards is important, rather than a single reward being pre-specified. This is consistent with Humphry (2011), who found that children were only motivated to continue using technology when they were able to choose their own reward. Whilst some studies reported that children with ASD are not motivated by social rewards (Humphry, 2011), the results in this study show that there can still be a preference for ‘cartoon’ faces to be embedded in computer-based applications (“*a silly face, then the tongue sticks out, and then the character says something*”- C2, during brainstorming). Both during the brainstorming and prototyping children introduced “smiley”/“funny”/“silly” faces and added speech bubbles to these faces in their prototypes, which indicates that these types of “social rewards” may be effective for children with ASD. This raises interesting questions concerning the social nature of rewards. Whilst faces are typically regarded as social stimuli, clearly drawings of faces cannot be interacted with in the way that people can be. This is consistent with research that has shown that whilst children with ASD have difficulty recognizing emotion in human faces, they do not have such difficulty with cartoon faces (Brosnan et al., 2015). Thus, the representation of ‘social’ stimuli within digital stimuli may still be desirable, but it will be of a different nature (e.g. cartoon faces as opposed to human faces) for children with ASD (see Grawemeyer

et al., 2012). Additionally, children with ASD understood what it was for a reward to adapt and develop, and not only showed a preference for a reward to change and develop but also generated ideas about what that development could entail. This is a novel finding, and is not obvious given the diagnostic criteria for ASD of a preference for sameness (APA, 2013).

Three groups of children with ASD, ID and both ASD and ID were involved in Study 2, with the ASD/ID group only contributing to the second activity. The aim of Study 2 was to identify: i) children's favorite reward topics; ii) their 'likes' and 'dislikes' of instances of reward topics; and iii) if children wanted rewards to develop, and, if so, could they create different levels of a reward that developed as children progress through the task.

The preferences for reward topics were consistent with South et al. (2005) and relatively consistent across groups 2 and 3, with Group 1 unable to undertake this activity. The results illustrate that South et al (2005) image topics preferred by children with AS and HFA can be extended to children with ASD and ID. This is important since many children with ASD also are likely to be diagnosed with ID. However, caution should be taken in generalizing these findings, as the number of children was small. With respect to the image instances for each of South's nine topics, preferences seem to be consistent across children and groups. Only two children chose an image instance different from the two instances they were provided with and most of the children appeared to favor the same image instance. For example, all children who preferred image topic Gadgets/Devices chose version "a" of the instance image which represented an iPad. This again highlights, that whilst personalization is desirable, there are consistencies across these groups with respect to what the personalized rewards should be. Again, it is difficult to generalize these results since the study was conducted with a small number of children.

Regarding the developing reward, children preferred a reward to reflect and to acknowledge their progress during a task, consistent with the findings in Study 1. Overall there was a pattern of consistency that may be useful in future development of extrinsic rewards embedded within technologies. Again, the specific nature of additional sound and animation to the reward stimulus appeared important. The presentation of generic rewards would therefore not be appropriate (see Humphry, 2011). Whilst this level of personalization may prove a challenge for designers, the present study suggests that limiting the choice of rewards to digital gadgets and devices (e.g. iPad) would be appropriate for these groups of children.

One novel contribution of the current research relates to the inclusion of children with ASD, ID and both ASD and ID within the participatory design process. The results indicate that for the most part these children could make a valuable contribution to the sessions. Children with ASD or ID participated fully in all the activities of identifying favorite rewards and how they could be designed within technology. Importantly, children with severe intellectual difficulties and compromised communication skills were also able to effectively participate within the participatory design process. Engaging with teachers to tailor the workshops to meet the requirements of the participants and then involving the teachers to work with the children during the workshops proved effective. Children who were just beginning to communicate intentionally and not yet speaking between 10 and 50 single words/signs/phrases, were able to contribute. The contributions they did make in identifying favorite topic instances were consistent with the other two groups.

In general, the findings highlight more commonalities than differences across the groups. The reward topics showed great consistency at the higher level (i.e. topic categories), but then there was variety in the specific instances of the reward topics chosen within the topic categories. Individual differences therefore existed more at the lower instance levels, again highlighting that there can be both similarities

in the types of preferred rewards as well as differences in the specific instances of those preferred rewards.

A further novelty of the research concerned the progressive nature of rewards for these groups of children. In many games and educational technological packages for neurotypical children the nature of rewards adapts and changes depending on the scale, difficulty or complexity of the activities or tasks. It is not known if this would be of benefit for children with ASD, ID or both. The children's liking for sameness, familiarity and expectations being met may have a bearing on whether or not adaptivity at the user interface is warranted for maintaining engagement. Changing and adapting rewards may be unsettling for these children. Our findings indicated that a level of change/adaptivity would be welcome. This was an unexpected finding of Study 1. However, there needs to be further theoretical and empirical work to hypothesize and identify what can change and what must stay the same. Could this concern the overall degree of change or is it more a question of keeping or losing perceptually salient or functional features? There was some support for the reward topic to stay the same and for the reward instances themselves to vary and for their representation to be incremental with added features. The children did appreciate that a 'bigger' reward was needed at the end of a task to reflect progression and their achievement. It was also clear however that sameness went beyond the use of technology to their expectations in other contexts. For instance, certificates of achievement are common rewards within a school setting, so it is unsurprising that these also figured in children's choices, and often towards the end of the tasks. In this case it is also important for any further research to not only address the need for sameness within the technology, but also across other contexts where there are common activities.

It should also be borne in mind that our findings are limited to a relatively small sample size and this along with the qualitative nature of the studies has implications for generalizability. We have shown some consistency between our results and those of South et al (2005) and Humphry (2011) in reward categories and preferences. However, it is not immediately obvious how to make higher level or more meaningful comparisons between our results and other studies investigating the nature of rewards in general across neurotypical and ASD and/or ID populations. Many factors will underpin the study outcomes from different types of reward, when they are given, how they are given, what for, and in what underlying circumstances, settings and contexts. Whilst we might cherish a long-term aim of developing a framework delineating reward vectors, at this early stage of investigating rewards for these populations the above potential differences make comparisons between study results particularly challenging.

Future research could also address important questions, such as 'what is to be rewarded?' Within the bounds of our research, a technological intervention relating to Social Story delivery is the context for rewarding the children, but what are we rewarding them for? Do we reward them for listening to or reading the story, or do we reward them for exhibiting less challenging behavior as a result of increasing social understanding (which is the point of the intervention), or perhaps both to different degrees and in different ways? Obviously, it is not the same as rewarding children within a learning environment for getting a correct answer to a question, but a more complex reward system. Furthermore, do we need to design rewards solely within the system or given that improved behavior away from the system is the goal, should there be an association between interaction with technology and in the world beyond technology? Do we reward inside the system (as described above) in combination with rewards and away from the system (e.g. chocolate or a piece of fruit)? There is little evidence that digital interventions generalize to real world situations (Grynzspan et al., 2014) and developing rewards within and beyond technology may represent a useful avenue of research.

It is intended that the Social Stories software that we have designed and implemented will provide a testing platform or infrastructure to address a series of research questions about rewards. From the

results of our studies we now know that children appreciate rewards. We also know the reward topic categories and potential reward instances children with ASD, ID and both ASD and ID prefer. Additionally, we have data and designs relating to rewards that change/adapt and some assumptions to be tested about what could or should stay the same or be allowed to differ. The next steps involve assessing the utility of rewards for these populations. Do rewards just engage and enhance the user experience or do they also underpin changes in understanding, learning and reductions in challenging behavior. Do they add value to an effective intervention by motivating children to engage with the intervention?

In summary, this paper makes a number of original contributions to both the reward and design technology literature and research. It raises a series of theoretical questions to be addressed about the role of sameness and difference in reward stimuli to be interacted with by children with ASD and/or ID. Additionally, it raises significant questions about the role of rewards in behavioral interventions. Methodologically it has shown that by adopting a robust, informed and flexible approach, it is possible to include children with ASD, and/or ID in a participatory design process. Empirically, it has provided data, currently very scarce, about three different groups of children offering novel solutions to design rewards to be embedded within digital technologies for children with ASD, ID or both. Practically, it has made design suggestions and implications, supported by an albeit limited evidence base, for utilizing specific categories of reward to be included within digital technologies.

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